

**Planetary Geophysics and Tectonics  
Final Report for grant NAGW-1928**

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Research supported by grant NAGW-1928 has addressed a variety of problems related to planetary evolution. One important focus has been on questions related to the role of chemical buoyancy in planetary evolution with application to both Venus and the Moon. We have developed a model for the evolution of the Moon (Hess and Parmentier, 1995) in which dense, highly radioactive, late stage magma ocean cumulates sink forming a core. This core heats the overlying, chemically layered mantle giving rise to a heated, chemically well-mixed layer that thickens with time. This mixed layer eventually becomes hot enough and thick enough that its top begins to melt at a pressure low enough that melt is buoyant, thus creating mare basalts from a high pressure source of the correct composition and at an appropriate time in lunar evolution. In work completed during the last year, numerical experiments on convection in a chemically stably stratified fluid layer heated from below have been completed. These results show us how to calculate the evolution of a mixed layer in the Moon, depending on the heat production in the ilmenite-cumulate core and the chemical stratification of the overlying mantle. Chemical stratification of the mantle after its initial differentiation is would trap heat in the deep interior and prevent the rapid rise of plumes with accompanying volcanism. This trapping of heat in the interior can explain the thickness of the lunar lithosphere as a function of time as well as the magmatic evolution. We show that heat transported to the base of the lithosphere at a rate determined by current estimates of radioactivity in the Moon would not satisfy constraints on elastic lithosphere thickness from tectonic feature associated with basin loading. Trapping heat at depth by a chemically stratified mantle may also explain the absence of global compressional features on the surface that previous models predict for an initially hot lunar interior.

For Venus, we developed a model in which the chemical buoyancy of crust and a depleted mantle layer stabilizes the lithosphere for long periods of time and provides a mechanism of episodic planetary evolution (Parmentier and Hess, 1992). Continued thickening of a residual depleted mantle layer eventually suppresses pressure release melting and the creation of depleted mantle. Continued cooling then allows the lithosphere to become heavier than the underlying hotter, undepleted mantle. This repeated instability can occur on time scales appropriate for episodic global resurfacing on Venus. We have also examined the role of the gabbro-eclogite phase transformation on crust and lithosphere stability and as a mechanism of crustal recycling in the absence of plate tectonics. Our work thus far concentrates on the scale of instability that would occur due to cooling or crustal thickening associated with horizontal shortening. Whether repeated overturn can explain the evolution of Venus depends in part on whether sufficient heat transfer can occur between overturns and on constraints provided by understanding observed surface features and evolution.

The following publications represent completed work supported by grant NAGW-1928.

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